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The students, faculty, and staff from New Mexico State University (NMSU) have completed their development of a nanosatellite called the Second NMSUSAT (NMSUSat2) as part of the University Nanosatellite Program. The satellite components have been finalized 2006-2007 academic year. This report captures the final design details the involvement of students in the program. This program is also being used as a model program for structuring capstone design classes in the Electrical and Computer Engineering program at NMSU. Over the project, a total of 58 students were actively involved in this program including 12 pre-freshman or high school students.

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College of Engineering

New Mexico State University Klipsch School of Electrical & Computer Engineering

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Authors(s): Stephen Horan

Sponsor: Air Force Office of Scientific Research

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SUMMARY

The students, faculty, and staff from New Mexico State University (NMSU) have completed their development of a nanosatellite called the Second NMSUSAT (*NMSUSat2*) as part of the University Nanosatellite Program. The satellite components have been finalized 2006-2007 academic year. This report captures the final design details the involvement of students in the program. This program is also being used as a model program for structuring capstone design classes in the Electrical and Computer Engineering program at NMSU. Over the project, a total of 58 students were actively involved in this program including 12 pre-freshman or high school students.

1 Mission Description

The faculty from the College of Engineering and the College of Arts and Sciences planed to develop a nanosatellite at New Mexico State University (NMSU) to be called the Second NMSU Satellite (*NMSUSat2)* as part of the University Nanosatellite Program. This satellite was developed based on the heritage of the earlier *3 Corner Satellite* (3CS) mission, the experience developed during the first *NMSUSat* design effort, and the existing engineering and science capabilities present on campus. The continued development of entire satellites at NMSU will enhance the engineering and education capabilities at NMSU. This section describes the overall objectives and approaches for designing the satellite.

1.1 Mission Objectives

The mission for the *NMSUSat2* is to perform science and technology experiments, in a time-sharing fashion, from low earth orbit using a university designed and built nanosatellite. The specific engineering technology experiments involve

1. Robotic Inspection
2. Attitude Control
3. Secure Communications

The science experiment involves UV background measurements of the earth's upper atmosphere. The UV measurements are useful for collecting background information that will be used to define a future cosmic ray satellite mission for NASA. The secure communications experiment is useful to AF and NASA mission designers to the performance of secure communications for low-power satellite links. Surface inspection of satellites is relevant to AF technology development. The attitude control development is necessary for long-term satellite development at NMSU.

1.2 Experiments

The *NMSUSat2* experiments and technology demonstrations have the following success criteria:

1. Within two weeks of being placed on orbit, the satellite shall achieve a nadir-pointing attitude to within ±10° as evidenced by measurements; the satellite shall maintain nadir pointing to within ±10° for at least 90% of the remaining useful mission time, as evidenced by measurements.
2. The Atmospheric UV Albedo measurement system shall sample the background at least once per minute over the eclipse side of 100 orbital cycles.
3. At least five photographs shall be taken every two weeks at each arm position.
4. The secure communications experiments shall consist of a minimum of five measurements, including one multi-station relays
5. The remote telemetry operation shall be able to relay received data from at least three continents to NMSU on at least three different days.
6. The goal of educational enhancement is to have at least 50 students involved with the project as part of their design education requirements.

1.3 Student Involvement

Students within the College of Engineering and the Engineering Physics program are eligible to participate in the *NMSUSat* program. Table 1 lists the students who have contributed to the project to date. Since the program began, 58 students have been involved in some form. This includes pre-freshman students who are transitioning to college from high school and are using the exposure to the satellite as part of their 'bridge" program and high school students using the program as part of their work experience. These students are usually first-generation college students.

1.4 Influence on NMSU's Educational Mission

The *NMSUSat* program has benefited the educational mission within NMSU. The faculty in the Klipsch School of Electrical and Computer Engineering are using the *NMSUSat* program as an example of a major, interdisciplinary design program for the senior design classes. In particular, documentation and presentation standards developed for the AFRL design reviews are being used as models for other design classes in the Electrical & Computer Engineering Department. The program has also been an integral part of the Mechanical Engineering senior design classes as well.

This past year, we have made a special effort to include pre-college students in the design process. We used two particular groups of students:

(a) Students from Mayfield high school who are part of the robotics competitions to work on the satellite arm
(b) Students from the Las Cruces public schools Excel program for gifted and/or students who need a more challenging program.

Both types of students were given actual design segments to work on.

Table 1 -- Student Participants in the *NMSUSat* Program at NMSU

***NMSUSat2* Student Participants**

Subsystem Communications	US Cit	M/F	Minority	UG/Grad	Major	Dates
1. TJ Evans	Y	M	N	UG	EE	5/05 -- present
2. Michele Chavez	Y	F	Y	Grad	EE	5/05 -- 05/06
3. Daniel Haverporth	Y	M	N	UG	EE	8/06 -- present
4. Elvira Esparza	Y	F	Y	UG	EE	01-07 -- present
5. Vanessa Murillo	Y	F	Y	UG	EE	01/07 -- present
Command & Data Handling						
1. George Kuchera	Y	M	N	UG	EE	5/05 -- present
2. Jace Ayers	Y	M	N	UG	EE	8/05 -- 12/05; 8-06 -- 12-06
3. Raquel Astorga	Y	F	Y	UG	EE	8/05 -- 05/06
4. Brian Duenas	Y	M	N	UG	EE	8/05 -- 05/06
5. Kwame Porter-Robinson	Y	M	Y	UG	EE	05/06 -- 08/06
6. Francisco Echeverria	Y	M	Y	High School	N/A	08/06 -- 11-06
7. Ryan Aaronscooke	Y	M	Y	UG	EE	1/07 -- present
8. Daniel Jaramillo	Y	M	Y	UG	EE	01/07 -- present
Attitude Control						
1. Ryan Orosco	Y	M	Y	UG	EE	8/05 -- 05/06
2. Terry Umbenhaur	Y	M	N	UG	EE	8/05 -- 05/06
3. Manny Diaz	Y	M	Y	UG	EE	8/05 -- 12/05; 08/06 -- 12-06
4. Patrick Gabladon	Y	M	Y	UG	EE	8/05 -- 05/06
5. Brian Collen	Y	M	N	UG	EE	01/06 -- 12-06
Thermal						
1. Brian Duenas	Y	M	N	UG	EE	8/05 -- 5-06
2. Matthew Cannon	Y	M	N	High School	N/A	05/06 -- 08/06
Sensors						
1. Jacob Greenwood	Y	M	N	UG	EE	08/05 -- 05/06
2. Richard Bloomfield	Y	M	N	UG	EE	08/06 -- present
3. Jon Chavez	Y	M	Y	UG	EE	01/06 -- 12-06
4. Daniel Chavez	Y	M	Y	UG	EE	01/07 -- present
Structures						
1. Eric Klasen	Y	M	N	UG	ME	8/05 -- 12/05
2. Aaron Paz	Y	M	Y	UG	ME	1/05 -- 5/05
3. Robert Gonzales	Y	M	Y	UG	ME	1/05 -- 08/05
4. Vanol Francois	Y	M	Y	Grad	ME	8/05 -- 05/06
5. Marc Masceranas	Y	M	N	UG	ME	8/05 -- 05/06
6. Brian Clason	Y	M	N	UG	ME	08/06 -- 12-06
7. Jhana Gorman	Y	F	Y	UG	ME	08/06 -- 12-06
8. Kevin Konchalski	Y	M	N	UG	ME	08/06 -- 12-06
9. Jesse Mcavoy	Y	M	N	UG	ME	08/06 -- 12-06
10. William McNair	Y	M	N	UG	ME	08/06 -- 12-06
11. David Walton	Y	M	N	UG	ME	08/06 -- 12-06
12. Carlos Levy	Y	M	Y	UG	ME	01/06 -- 08/06
13. Jeremy Bruggemann	Y	M	N	UG	ME	05/06 -- present

NMSUSat2 Student Participants

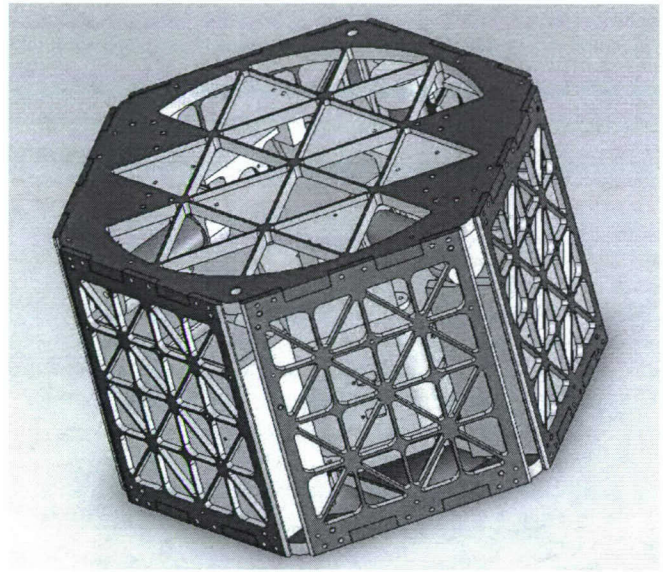
Subsystem Structures	US Cit	M/F	Minority	UG/Grad	Major	Dates
14. John McNamara	Y	M	N	UG	ME	01/07 -- present
Power System						
1. Antonio Lopez-Caamano	N	M	N	UG	EE	8/05 -- 05/06
2. Eduardo Galvan	Y	M	Y	UG	EE	8/05 -- 12/05
3. Christa Carlowe	Y	F	N	UG	EE	08/06 -- present
4. John Hood	Y	M	Y	UG	EE	08/06 -- 12-06
5. James Riggins	Y	M	N	UG	EE	08/06 -- present
6. Jermiah Rios	Y	M	Y	UG	EE	08/06 -- present
7. Fernando Moncayo	Y	M	Y	UG	EE	01/07 -- present
8. Jacob Walters	Y	M	N	UG	EE	01/07 -- present
Management						
1. Lee Finley	Y	M	N	Grad	EE	1/05 -- 12/05
2. Matthew King	Y	M	N	Grad	EE	1/06 -- 5/06
3. Arthur Sanchez	Y	M	N	High School	N/A	08/06 -- 12-06
Outreach Students						
1. Jonathan Barreras	Y	M	Y	pre-freshman		05/05 -- 07/05
2. Jesus Carrillo	Y	M	Y	pre-freshman		05/05 -- 07/05
3. Michael Garcia	Y	M	Y	pre-freshman		05/05 -- 07/05
4. Marcos Ortiz	Y	M	Y	pre-freshman		05/05 -- 07/05
5. Gabriel Varela	Y	M	Y	pre-freshman		05/05 -- 07/05
6. Alyx Giacamelli	Y	F	N	High School		06/06 -- 08/06
7. Julie Harris	Y	F	N	High School		06/06 -- 08/06
8. Tamra Overcast	Y	F	N	High School		06/06 -- 08/06
9. Daniel Castelo	Y	M	N	High School		06/06 -- 08/06

2 *NMSUSat* Flight Competition Review Presentation

- The following pages provide the Flight Competition Review presentation that was presented at the FCR in 2007.

Nanosat 4 FCR

NMSUSat2 Team
New Mexico State University
College of Engineering



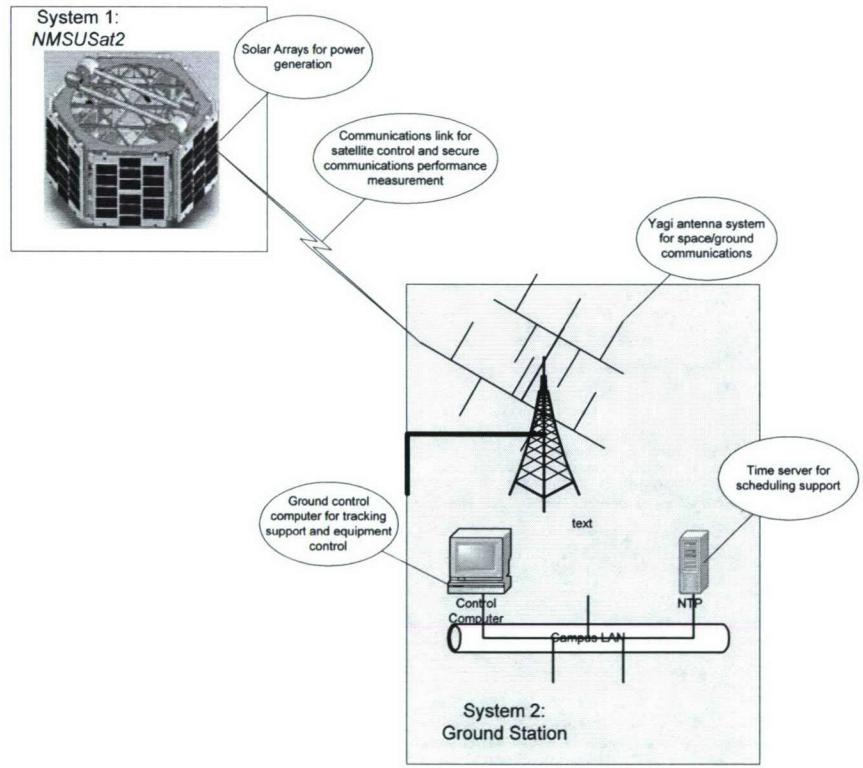
NM STATE

Topics

- Mission Overview
- Design Changes
- Mechanical Analysis & Test Status
- Electrical Analysis Status
- Subsystems
- Questions

Mission Overview – Mission Statement & Objectives

- **Project Mission Statement**
  - The mission for the *NMSUSat2* is to perform science and technology experiments, in a time-sharing fashion, from LEO using a university designed and built nanosatellite.
- **Project Technology Demonstration**
  - Satellite Inspection
  - Measure Inertial Properties
  - Secure Communications
- **Project Space Science Measurement**
  - Atmospheric UV Albedo Measurement

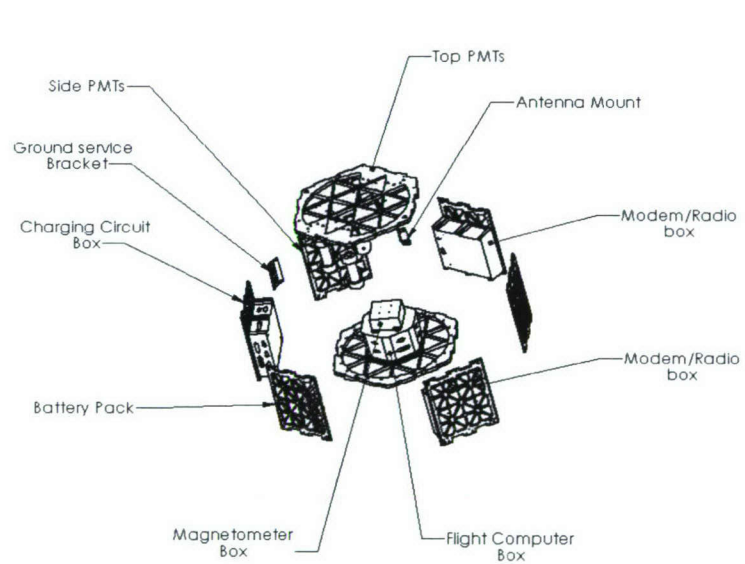


Mission Overview – Mission Relevance

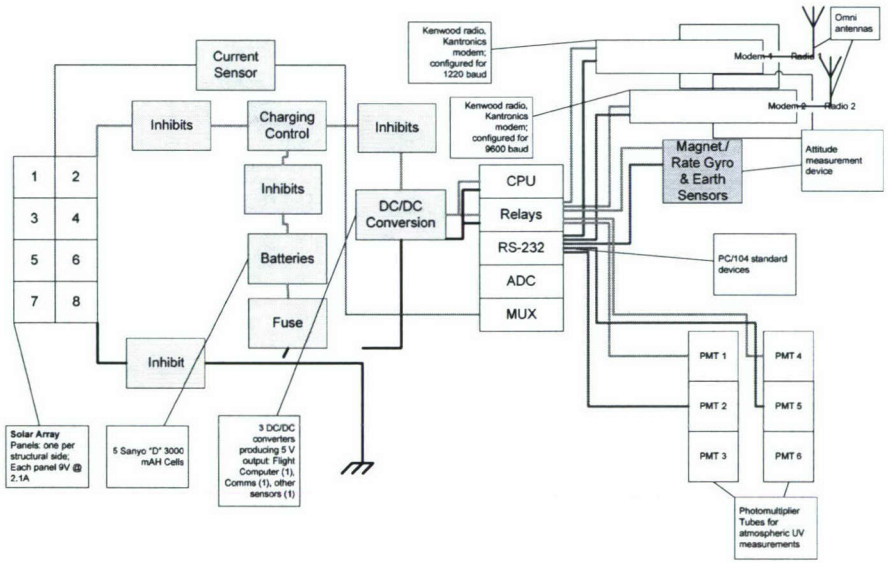
- **Secure Communications Measurements:** These measurements are useful to mission designers to assess the performance of secure communications for low signal-to-noise-ratio satellite links.
- **Near Ultra Violet Measurements:** This will assist astrophysicists in developing sensor suites for space-based measurements of cosmic ray interactions with the earth's atmosphere; current data set from all investigators at all locations is ~ 100 min.
- **Charging Control Circuit:** Verify optimal solar energy conversion, and supply rated voltage and current to subsystems during eclipse operations.
- **ADS & Earth Sensors**: Effectively determine satellite position relative to earth.
- **Health and Welfare:** Determine satellite temperatures and currents at a minimal 5 minute interval.

Mission Overview – System Diagram

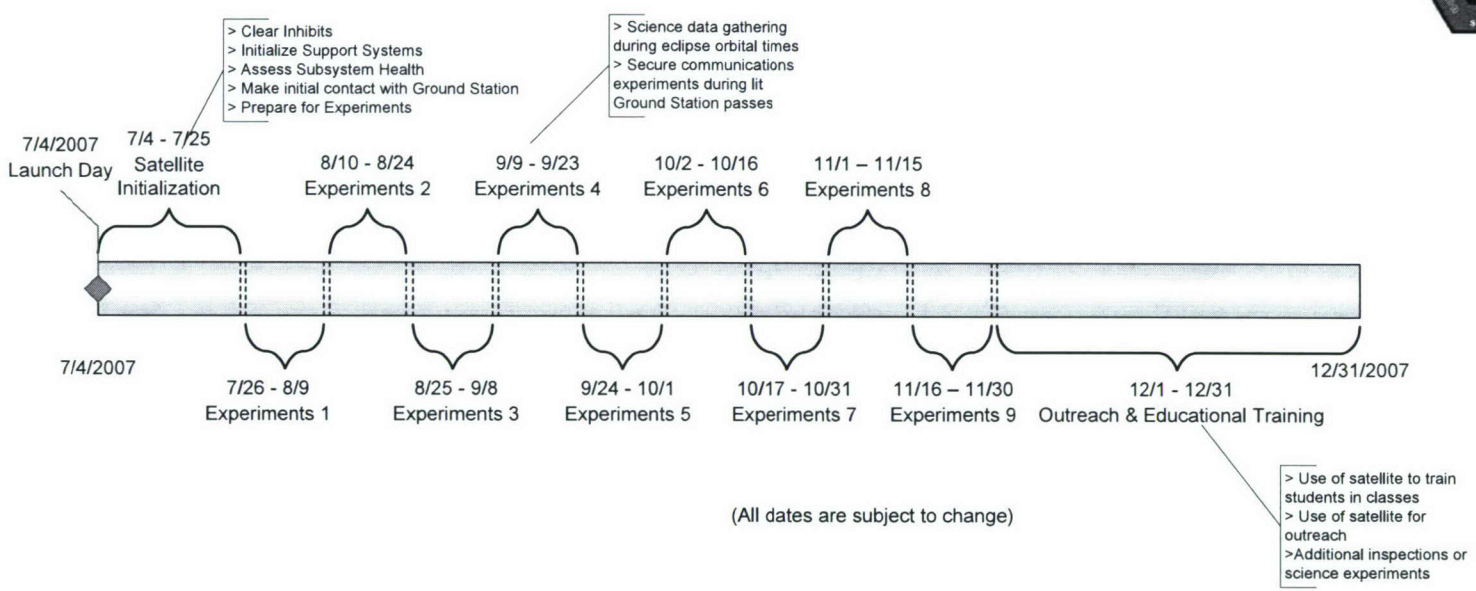
Mechanical Configuration



Electrical Configuration



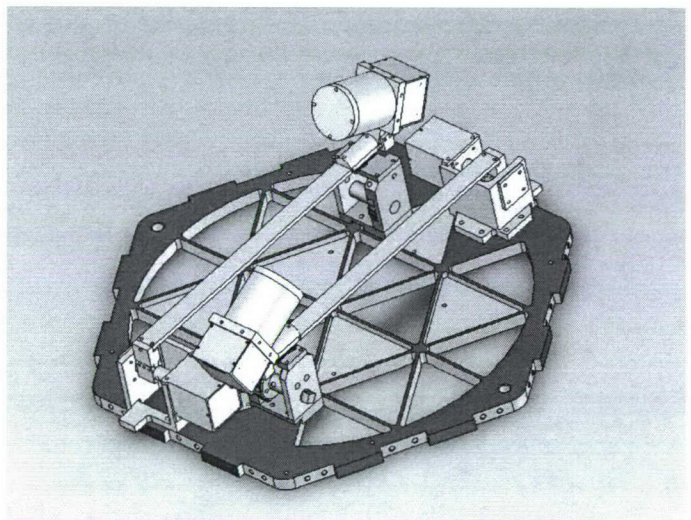
Mission Overview – ConOps



- Use moon phases and orbit parameters to develop a schedule to perform the science measurements over a six-month period
- Use satellite for public outreach after science and technology main mission accomplished.

Design Changes

- Robotic arms eliminated from final design
  - Power constraints for the design parameters
  - Time constraints
- Surface inspection system eliminated
  - Software integration issues



Mechanical Analysis & Test Status

	Bus Structure		Robotic Arms	
Behavior	**Analysis**	**Test**	**Analysis**	**Test**
Structural Strength	25%	0%	100%	0%
Stiffness (Modal Frequency)	25%	--	100%	--
Random Vibration / Acoustic	--	0%	--	0%
Shock	--	0%	--	0%
Mass Properties	100%	0%	100%	50%
Thermal Vacuum	100%	0%	100%	0%
Pressure Profile	0%	0%	0%	0%
Bake Out	--	0%	--	0%
Envelope Verification	100%	0%	100%	0%

Electrical Analysis Status

Subsystem	Test	Results
Flight Computer	Integration Test with Subsystems	**Successful** – Able to communicate with all subsystems.
Power System	Initial launch Simulation and Load Test	**Successful** – Completed initial separation and initially charged batteries for 23 min and 15 sec. Operated in darkness for 45 min with equivalent load.
Comms System	Acceptance Tests: Modems- Before/After Modifications Radios – Before/After modifications	**Successful-** modems and radio are flight qualified. Test on one radio pending.
Science Sensors	Before Modification Testing After Modification Testing	**Pending** – After modification test.

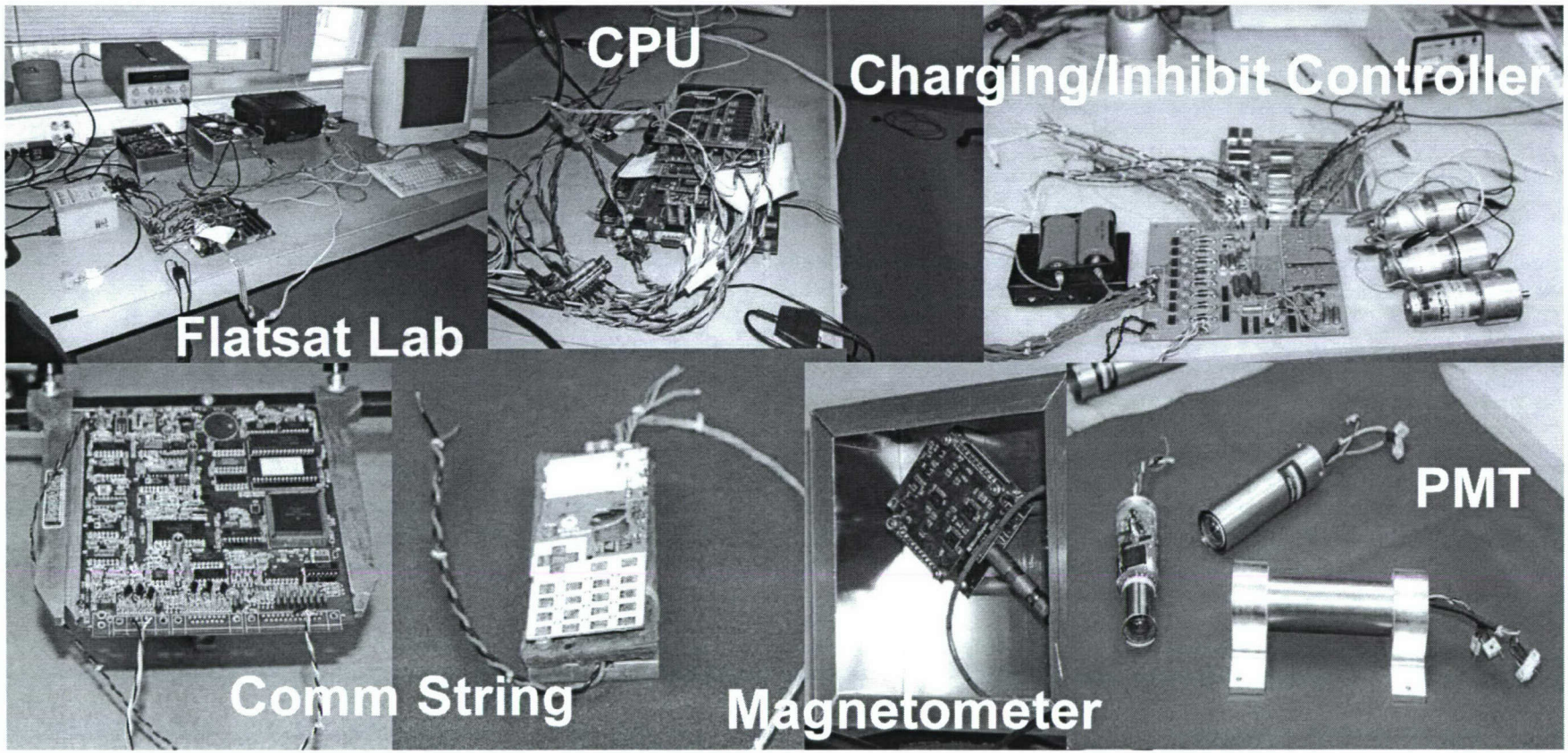
Electrical Analysis Status

Subsystem	Test	Results
ADS	IMU, Magnetometer, and Gyroscope Acceptance/Post Modification Testing	**Successful** – All results verified correct operation of ADS.
Earth Sensors	Individual Earth Sensor Tests, Integration Tests	**Successful** – Successfully verified position of the IR source.
Health & Welfare	Tested Muxes and ADC.	**Successful** – Able to take accurate measurements.

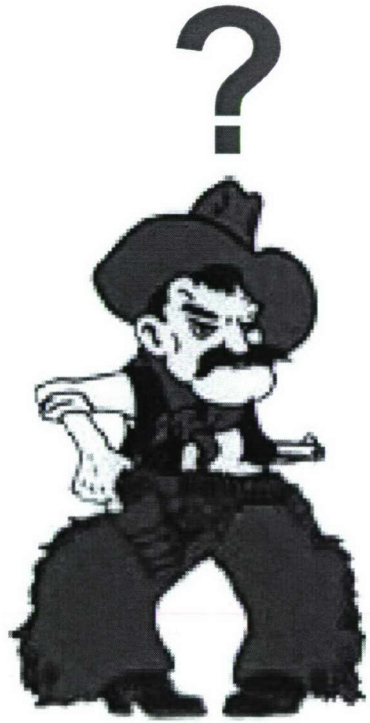
Student Participation and Education

- EE Students ~35
- ME Students ~32
- High School Students (at least 2)

NMSUSat2 Subsystems




NMSU Sat-2
NEW MEXICO
STATE UNIVERSITY



3 Follow-On

The NMSU satellite was not selected for the final flight. Because the design is capable of performing the science mission and most of the components were completed, the team wanted to look for other venues. As of this date, the team has petitioned the Columbia Scientific Balloon Facility for an opportunity to ride as a secondary to either a scientific balloon project or as part of an engineering flight. The CSBF is working with NMSU to make this possible.